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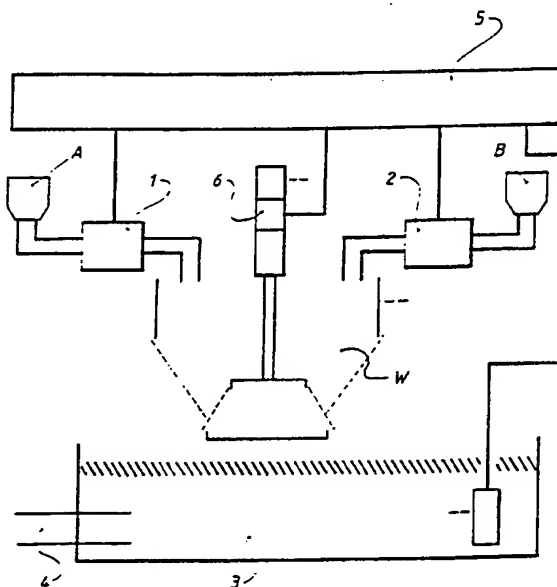
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(54) Title: **LIVESTOCK FEEDING CONTROL SYSTEM**

(57) Abstract

A livestock feeding system for providing feedstuff to a population of animals or birds under intensive rearing is described, including first and second feed storage bins (A and B) containing first and second feedstuffs having differing percentage contents of a given nutritional element, and a proportioning and delivery system (1, 2, 3, 4) supplied by the bins (A and B) to deliver to the animals at a controlled rate, a mixture of the first and second feedstuffs in the ratio necessary to deliver to the animals or birds their daily requirement of the said nutritional element. A method of controlling the feeding of a population of animals is also described, the method comprising the steps of: a) establishing stores of a first and a second feedstuff having differing percentage contents of a given nutritional element; b) determining at intervals the current requirement of the population for the said nutritional element and the total feed weight requirement of the population; c) calculating the proportions in which the feedstuffs must be mixed to achieve the required feed weight having the required percentage content of the said nutritional element; and d) delivering the feedstuffs to the population in those proportions and amount over the interval until the next calculation.



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LIVESTOCK FEEDING CONTROL SYSTEM

The present invention relates to the feeding of livestock, and is particularly concerned with the control of the protein content in the animal feedstuff fed throughout the animals' growing cycle.

In the intensive rearing of animals and poultry, it is known that the daily protein requirement of the animals varies during their life cycle relative to their age and level of production. The protein level required in their feedstuff is high in the initial stages of the rearing cycle when the animals are relatively young, and reduces during the growing cycle as the animals approach a saleable condition. Hitherto, it has been common practice to provide the animals with a series of different feedstuffs during various stages of their development, starting with a feedstuff high in protein percentage and changing at intervals to feedstuffs of lower percentage. The feedstuff appropriate to the animals' current state of development is often dispensed from a central feed bin via hoppers to the individual animals by mechanical conveyors. Depending on the type of animals concerned, up to six different feedstuffs may be involved, fed in sequence over the growing cycle of the animals.

In a conventional feed system, feed is contained in a feed bin and from there it is delivered to a feed hopper in the animal house. From the feed hopper the feed is often mechanically conveyed to feed troughs or other receptacles from which the animals or birds

eat. Sensors in the troughs or hoppers detect a lowering of the feed level, and the delivery system is operated in response to the sensors to keep the troughs and hoppers filled from the feed bins. At specific times during the growing cycle of the animals, the feedstuff delivered to the feed bins is changed to a lower protein feed, this being done when the feed bin is replenished, by simply filling the feed bin with the new feed. The new feed is placed on top of any of the old feed still remaining in the feed bin. Clearly, control over the amount of protein eaten per day by the animals or birds during the changeover period is impossible with such a system, since an uncontrolled mixture of the two feed stocks is delivered. The animals' average daily intake of protein can only be assessed approximately, until all the old feed has passed through the system and the new feed is being supplied unadulterated to the animals.

It will be appreciated that, since each feedstuff is fed to the animals for a given period of time, then the feedstuff must be of a sufficiently high protein percentage to ensure that the required daily protein intake requirements of the animals or birds at the beginning of this interval is reached. As the animals' or birds' appetites increase with age faster than their protein needs, this means that the daily protein intakes throughout the remainder of the period in which this feedstuff is given is higher than the animals' actual protein requirement, and thus expensive high-protein feedstuff is in effect wasted. It has also been noted that the sudden change

in the feed composition is usually followed by a loss of appetite and a consequent temporary reduction in growth rate.

In order to avoid the disadvantages of the prior art methods of intensive animal feeding, the present invention seeks to provide a system which can accurately control the protein levels in animal feedstuffs from day to day, based on an appreciation of the daily protein (more specifically amino acid) requirements of the animals being reared together with the quantity of feed eaten. By progressively varying the protein levels and composition of the feedstuff, the animals' daily needs for protein are exactly matched by the composition and protein level in the feedstuff fed, taking into account the actual daily appetites of the animals. The present invention allows feed costs to be reduced without affecting the growth rate or carcass quality or production of the birds or animals produced. Indeed, by matching the daily needs for protein more exactly, growth rate, carcass quality and production may actually be improved.

According to a first aspect of the present invention, a livestock feeding system for providing feedstuff to a population of animals or birds under intensive rearing includes first and second feed storage bins, containing first and second feedstuffs having differing percentage contents of a given nutritional element, and a proportioning and delivery system supplied by the bins to deliver to the animals at a controlled rate, a mixture of the first and second

feedstuffs in the ratio necessary to deliver to the animals or birds their daily requirement of the nutritional element.

The system includes control means which sense the rate of consumption of feed by the animals, in order to be able to calculate the correct amount of feed required by the animals or birds on a day to day basis. The control means further includes registers which store information relating to the protein content of the feedstuffs in the first and second bins, the daily protein requirements of the animals, and both the theoretical and actual daily consumption of feedstuffs by the animals. This information is used to calculate the ratio of the first and second feedstuffs which must be blended to achieve the required protein content in the mixed feed necessary to deliver the daily protein requirements of the animals or birds having regard to their daily appetites for feed.

To calculate the proportions of the feedstuffs required when two feedstuffs are used, the proportion of first feedstuff in the mixed feed is found by dividing the difference between the percentage content of protein in the second feedstuff and in the mixed feed, by the difference in percentage content of protein in the first and second feedstuffs. Likewise, the proportion of second feedstuff in the mixed feed is found by dividing the difference between the percentage content of protein in the first feedstuff and in the mixed feed, by the difference in percentage content of protein in the first and second feedstuffs.

The system of the present invention can be installed either by adapting an existing feed installation, or by installing a purpose-built system.

The present system uses information on the age, type and number of animals in the house to deliver accurately to the animals the correct quantities of protein (specifically amino acids) each day, by ensuring that the protein content of the feed is accurately matched to the animals' daily feed intakes or appetites at that time.

According to a second aspect, the present invention provides a method of controlling the feeding of a population of animals to optimise efficiency, comprising the steps of:

- a) establishing stores of a first and a second feedstuff having differing percentage contents of a given nutritional element;
- b) determining at intervals the current requirement of the population for the said nutritional element and the total feed weight requirement of the population;
- c) calculating the proportions in which the feedstuffs must be mixed to achieve the required feed weight having the required content of the said nutritional element;
- d) delivering the feedstuffs to the population in those proportions and amount over the interval until the next calculation

An example of the system and method of the present invention will now be described in detail, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic view of the system.

Figure 2 is a schematic overview of the control system; and

Figure 3 is a schematic diagram showing the derivation of a feedstuff ratio.

As seen in Figure 1, the exemplary system comprises two feed bins A and B, the first of which (A) is kept filled with a high-protein feed, and the second bin (B) is supplied with either a low-protein feedstuff or a feed grain such as wheat, barley or oats. It will be readily appreciated that the high-protein feedstuff must have a percentage protein content at least as high as the highest percentage requirement of the animals. Likewise, the low-protein feed must have a percentage protein content equal to or less than the lowest percentage requirement of the animals.

The feed bins each have an auger 1, 2 associated with their respective outlets or other such means of controlling discharge and are able selectively to discharge feed into a weigher W, from whence the feed is carried or dropped to a mixer 3. The mixer supplies a distribution apparatus 4 to take feed to feeding receptacles in the animal house (not shown).

In operation, a daily protein requirement is established by calculation based on the number of animals in the house, the type of animal concerned, and the stage of the growing or production cycle reached. In an 'automatic' mode of operation, this calculation is performed by a control unit linked to actuators in the augers 1 and 2 of feed hoppers A and B and to the actuator 6 of weigher W, based on information kept in memories in the control unit.

Referring to Figure 2, the top line of the diagram shows the various memories of the control unit. M1 is a store recording the average daily protein (more specifically amino acid) requirement for the type of animal concerned, this information being computed from the performance objectives of the producer and the genetic potential of the animals or birds. M2 records the number of animals or birds in the house, this figure being automatically updated daily after an inspection of the house and subtraction of the number of dead animals found. Memory M3 records the amount of feed delivered to the animals the previous day. Memories M4 and M5 record the protein content and other nutritional data relating to the feedstuffs in the two feed bins, this information being updated each time fresh feedstuff is added to either bin. The analytical data that may be updated includes protein, amino-acids or other nutritional information relating to the batch or load of feedstuffs delivered and deposited in bins A and B. This data, together with the weights of feedstuffs delivered to each bin and their costs, may be entered into the

control system memories either manually via an input keyboard or automatically via sensors in the feed storage bins. A system in use currently is near infra red (NIR) reflectance spectrophotometry, which provides a rapid means of estimating the chemical and nutritional components of feedstuffs. The data provided by such equipment may be entered into the control system manually or directly by modem or other electronic means.

The data is then used by the controller so that the computations carried out in the 'automatic' mode of action may be based on actual values of the feedstuffs as delivered, rather than their theoretical values based on predictions or expectations.

The control unit derives the total protein requirement for a day from the data in memories M1 and M2 by multiplying the average requirement of the animals at the current age by the number of animals present.

The amount of feed eaten the previous day (it is assumed that all feed supplied is eaten) provides a basis for estimating, by the addition of values from an increment table (see Figure 2), the amount that will be consumed on a given day. This estimate, when combined with the total protein requirement of the animals, allows the calculation of the proportion of the feed to be supplied that must be protein.

This in turn, taken with the data on the protein contents of the feeds in bins A and B, allow the calculation of the ratio in which feeds from bins A and B must be mixed to achieve the required total weight and protein content of the mixed feed to be delivered.

This ratio is, via the controller 7, then used to control the augers 1 and 2 (Figure 1) which deliver feed from bins A and B sequentially to the weigher W and thence to the mixer 3 to produce the mixed feed for the animals. The mixed feed is transported by the distribution apparatus 4 to the animal house 8.

As an example (Figure 3), consider that a flock of 29,200 birds (the latest figure from M2) requires a protein intake per bird of 1,000 mg Lysine on a given day (this figure is retrieved from M1 each day). The total Lysine requirement for the flock is thus 29.2 kg this day. The amount of feed consumed the previous day was 3.5 tonnes (from M3) and the increase in feed requirement per bird is 5.14 gm (this figure is taken from a table of increments), thus an extra 0.15 tonnes are needed for 29,200 birds, giving a mixed feed weight total of 3.65 tonnes.

Since 29.2 kg of Lysine must be provided by this feed, then the Lysine content of the mixed feed is 0.8% by weight (N).

From M4, the Lysine content of the feed in bin A is known to be, say, 1.1% (A). Likewise, M5 shows the Lysine content of the feed in bin B to be, say, 0.35% (B). Using the formula $\frac{N-B}{A-B} \times 100$, the percentage of feed required from bin A is calculated, and using the

formula $\frac{A-N}{A-B} \times 100$, the percentage of feed from bin B is calculated. Using these exemplary figures, it is seen that

$\frac{0.8-.35}{1.1-.35} \times 100$ gives 60% of the mixed feed to come from bin A, and

$\frac{1.1-0.8}{1.1-0.35} \times 100$ gives 40% of the mixed feed to come from bin B.

Feed is then delivered from the bins A and B to the weigher W. If the weigher W has a capacity of 25 kg, then 60% of that capacity is to be taken up by feed from bin A, thus 15 kg of feed from bin A is required. An auger is operated to deliver feed to the weigher until 15 kg are present. A second auger is then operated to deliver feed from bin B until 10 kg have been delivered. The 25 kg of feed is then passed to a mixer wherein the two feeds are thoroughly mixed. The mixed feed is then delivered to the animal house, and further batches of 25 kg are measured, mixed and delivered until the day's total of 3.65 tonnes has been delivered.

As an alternative to the 'automatic' mode of operation, wherein each day's feed requirement is calculated and the feed mixed accordingly, there is foreseen a preset or 'planned' mode of operation wherein each day's feed to be supplied is determined in advance of the start of the feeding cycle, and the information stored. As the feeding cycle progresses, the feed data is progressively accessed to control the amount and proportion of feeds to be delivered from storage bins. Table I is an example of a table showing the proportion of feed to be delivered from a low-protein feed bin for each day of the feeding cycle.

TABLE I

<u>Day</u>	<u>% Feed BIN A</u>	<u>Day</u>	<u>% Feed BIN A</u>	<u>Day</u>	<u>% Feed BIN A</u>
1	0	23	14	45	20
2	0	24	15	46	21
3	0	25	16	47	100
4	0	26	16	48	100
5	0	27	17	49	100
6	2	28	18	50	100
7	4	29	18	51	100
8	6	30	19	52	100
9	8	31	20	53	100
10	10	32	20	54	100
11	12	33	9	55	100
12	14	34	10	56	100
13	16	35	10	57	100
14	18	36	11	58	100
15	18	37	12	59	100
16	18	38	13	60	100
17	19	39	14	61	100
18	20	40	15	62	100
19	12	41	16	63	100
20	12	42	17	64	100
21	13	43	18		
22	14	44	19		

To arrive at the daily figures, various factors must be taken into account, such as the expected feed intakes, the required protein/amino acid/ nutrient requirements, the planned dates and contents of replenishments of the bins, and the feed analysis of the feeds used in the bins.

Prior to the start of the feeding cycle, the table exemplified in Table I is set up, and for each day of the cycle the feed ratio is delivered to the stock in accordance with the day's figure from the table. In a simple form, the data may be manually calculated and keyed-in to the system memory.

In another alternative mode of operation, an operator may key in each day the required feed ratio and amount, thus providing a 'manual' mode of operation.

The system controlling the blending of feed may also be shut down, providing a 'disabled' mode in which the feed is delivered from the bins in the conventional manner.

By providing four alternative modes of operation, a flexibility is obtained by means of which an operator may change from 'planned' to 'automatic' or 'manual' or 'disabled' at any time during the feeding cycle, and may select any mode of operation at any time.

By preparing a mixture of the two basic feedstuffs each day so as to have the protein content calculated to supply the ideal amount of protein for each animal, the objectives of economic use of feed and the avoidance of sudden variations in the feedstuff which interrupt the animals' feeding pattern are obtained. It is also foreseen that a system using three or more storage bins containing

three or more different feed stocks may be proportioned and mixed, to enable a mixed feedstuff having closely controlled percentage contents of two different nutritional elements to be delivered to the animal population.

The system is preferably controlled by a microprocessor programmed to perform the feed calculations from data stored in memories. The data in the memories may include data on the daily protein requirement and daily feed intake requirement of a number of different animals or breeds or such basic data of a genetic nutritional and production requirement nature from which such data may be derived, so that an operator may select the appropriate data on which the system's calculations are based. The system may also provide for an override feature, allowing the operator to vary the feed ratio, the feed protein content or the feed quantity from the calculated amounts. The animals' or birds' drinking water may also be appropriately enriched with added proteins or their components or vitamins or minerals, so that the desired daily intakes of a second or third nutritional element may be delivered accurately on a daily basis.

The system also finds utility in the farming of fish, and can be used to provide a mixed feed of progressively varying protein content suitable for rearing various species of farmed fish.

CLAIMS

1. A livestock feeding system for providing feedstuff to a population of animals or birds under intensive rearing includes first and second feed storage bins, containing first and second feedstuffs having differing percentage contents of a given nutritional element, and a proportioning and delivery system supplied by the bins to deliver to the animals at a controlled rate, a mixture of the first and second feedstuffs in the ratio necessary to deliver to the animals or birds their daily requirement of the said nutritional element.

2. A system according to Claim 1, including first and second storage bins, delivery means for delivering a predetermined quantity of feed from each bin, and distribution means for transporting the feeds to the population, wherein the delivery means is controlled by a control means which determines the proportion of feed to be delivered from the first and second bins in accordance with the daily nutritional requirements of the population.

3. A system according to Claim 1 or Claim 2, wherein the proportion of feed to be delivered from the first and second storage bins is calculated daily by determining the protein requirement of the population and adjusting the proportion on the basis of data relating to the protein contents of the feed in the storage bins.

4. A system according to Claim 2 or Claim 3, wherein the control means includes memory registers to store data regarding the number of animals in the population, the daily feed consumption of each animal, the daily protein requirement of each animal, and the protein contents of the feeds in the storage bins, and processor means to calculate each day the total weight of feed required by the population, the daily total protein requirement of the population, and the ratio of feeds from the first and second storage bins which will provide the required feed weight with the necessary protein content.

5. A system according to any preceding Claim, wherein display means are provided in association with the control means to enable the contents of the memory registers to be displayed, and input means are provided to enable an operator to amend data stored in the memory registers.

6. A system according to any preceding Claim, wherein feeds are delivered from their respective storage bins to a mixer, and are thoroughly mixed prior to distribution.

7. A system according to any preceding Claim, wherein three or more different feedstuffs are stored in respective storage bins and are proportioned, delivered and distributed to provide controlled levels of two or more nutritional elements.

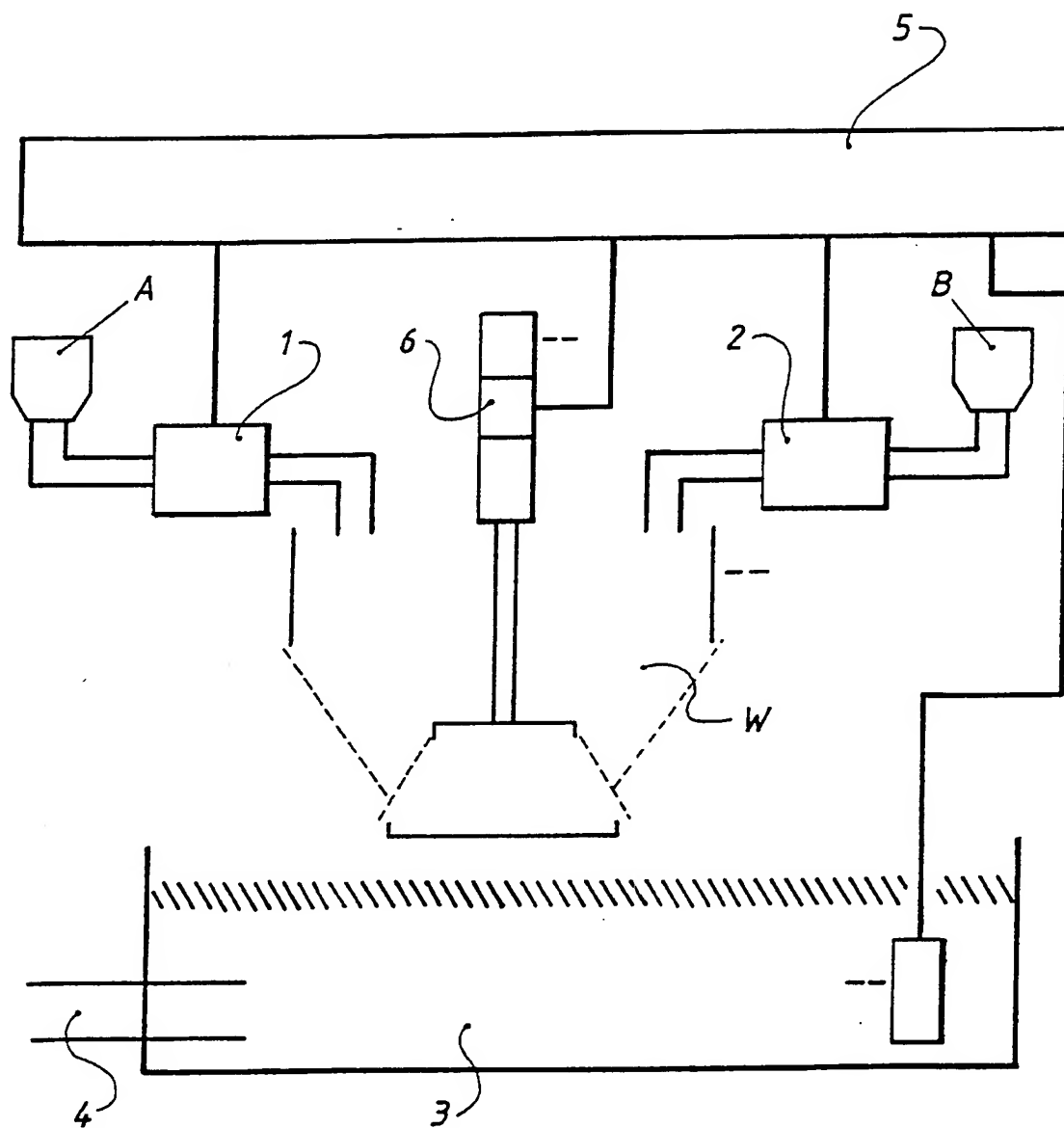
8. A method of controlling the feeding of a population of animals, comprising the steps of: a) establishing stores of a first and a second feedstuff having differing percentage contents of a given nutritional element; b) determining at intervals the current requirement of the population for the said nutritional element and the total feed weight requirement of the population; c) calculating the proportions in which the feedstuffs must be mixed to achieve the required feed weight having the required percentage content of the said nutritional element; and d) delivering the feedstuffs to the population in those proportions and amount over the interval until the next calculation

9. A method according to Claim 8, wherein the determination is made on a daily basis by multiplying the number of animals in the population by an individual animal's daily requirement for the said nutritional element.

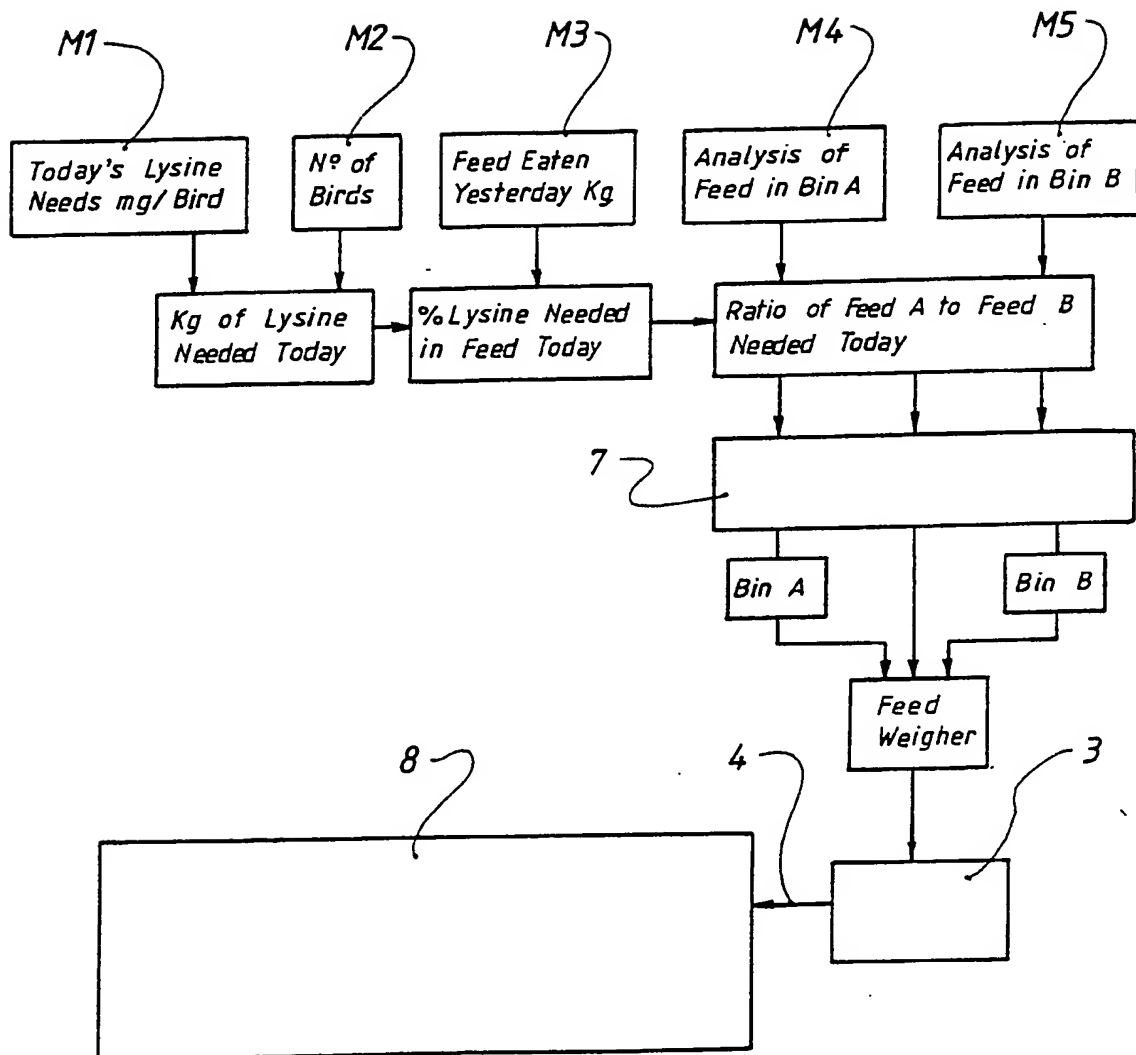
10. A method according to Claim 8 or Claim 9, wherein the proportion of second feedstuff in the mixed feed is calculated by dividing the difference in percentage content of nutritional element in the first feedstuff and in the mixed feed by the difference in percentage content of nutritional element in the first and second feedstuffs.

11. A method according to Claim 8, Claim 9, or Claim 10, wherein the nutritional element is protein.

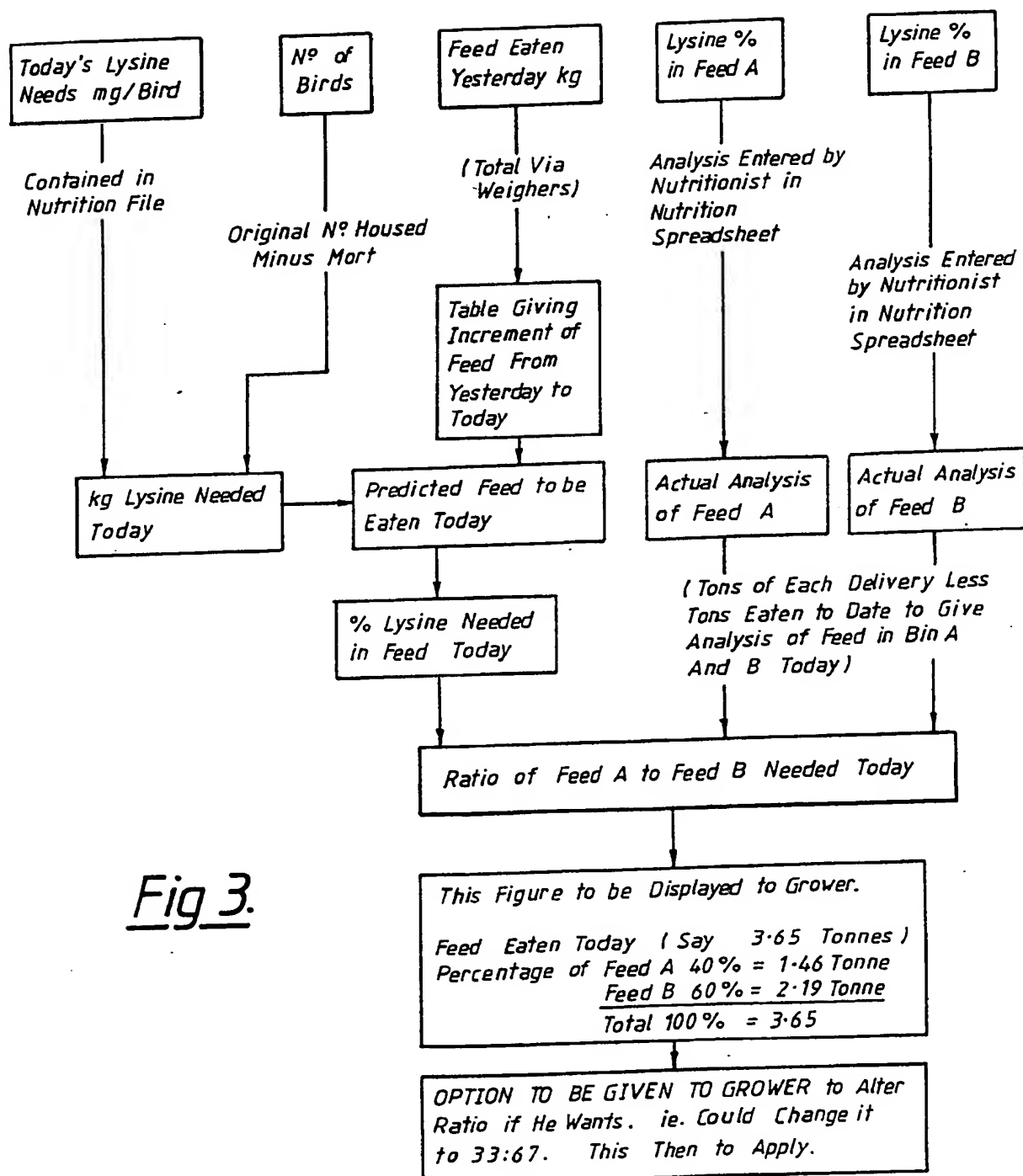
12. A method according to any of Claims 8 to 11, wherein the feedstuffs are mixed prior to delivery to the population.

Fig 1.

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Fig 2.

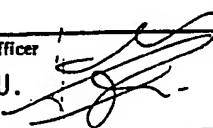
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Fig 3.

INTERNATIONAL SEARCH REPORT

PCT/GB 91/01531

International Application No

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 A01K5/02; A01K29/00		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	A01K	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	US,A,4 712 511 (ZAMZOW) 15 December 1987 see column 4, line 31 - column 7, line 14; figures 1-6 ---	1-12
X	US,A,4 517 923 (PALMER) 21 May 1985 ---	1,2,5,8, 9-12
A	see column 3, line 24 - column 4, line 60; figure 1 ---	3,4,6,7
A	DE,A,3 321 731 (FAHLBUSCH) 20 December 1984 see the whole document ---	1-12
A	WO,A,8 203 159 (BLICHER) 30 September 1982 see page 1 - page 9 ---	3,7,8, 11,12
A	WO,A,8 809 119 (ALBANO) 1 December 1988 ---	
A	EP,A,0 285 596 (VOGL) 5 October 1988 ---	
	-/--	
<p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
22 NOVEMBER 1991	- 4. 12. 91	
International Searching Authority	Signature of Authorized Officer	
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A,4 117 954 (PELLETIER) 3 October 1978 ---	
A	US,A,3 171 385 (DECKER) 2 March 1965 ---	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9101531
SA 51075

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4712511	15-12-87	None	
US-A-4517923	21-05-85	None	
DE-A-3321731	20-12-84	None	
WO-A-8203159	30-09-82	AU-A- 8275782 EP-A, B 0073806	06-10-82 16-03-83
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